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IS 6162-2 (1971): Paper Covered Aluminium Conductors, Part II: Rectangular Conductors [ETD 33: Winding Wire]



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“Knowledge is such a treasure which cannot be stolen”

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IS : 6162 (Part II) - 1971

Indian Standard

**SPECIFICATION FOR PAPER
COVERED ALUMINIUM CONDUCTORS**

PART II RECTANGULAR CONDUCTORS

(Third Reprint DECEMBER 1986)

UDC 621.315.334.6 : 621.315.55 [669.71]



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**INDIAN STANDARDS INSTITUTION
MANAK BHAYAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110008**

AMENDMENT NO. 5 SEPTEMBER 1993
TO
IS 6162 (Part 2) : 1971 SPECIFICATION FOR
PAPER - COVERED ALUMINIUM CONDUCTORS
PART 2 RECTANGULAR CONDUCTORS

(Page 8, clause 8) — Delete and renumber the rest.

(Page 15, Appendix E) — Delete.

(Page 1, Appendix F, Amendment No. 4) — Substitute 'RECTANGULAR'
for 'ROUND' in the title.

(ETD 33)

Reprography Unit, BIS, New Delhi, India

Indian Standard

SPECIFICATION FOR PAPER COVERED ALUMINIUM CONDUCTORS

PART II RECTANGULAR CONDUCTORS

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Indian Standard
**SPECIFICATION FOR PAPER
COVERED ALUMINIUM CONDUCTORS
PART II RECTANGULAR CONDUCTORS**

0. FOREWORD

0.1 This Indian Standard (Part II) was adopted by the Indian Standards Institution on 14 June 1971, after the draft finalized by the Winding Wires Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard has been formulated in view of the increasing use of aluminium as electrical conductor for windings of electrical machines, such as transformers.

0.3 This standard (Part II) shall be read in conjunction with IS : 6160 - 1971*.

0.4 This standard is one of a series of Indian Standards on winding wires. A list of standards published so far in this series is given on P 18.

0.5 In the preparation of this standard, assistance has been derived from the following:

B.S. 2776 : Part 2 : 1956 Paper covered rectangular copper conductors for transformer windings. British Standards Institution.

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2 - 1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 General — This standard (Part II) gives requirements and tests for solid aluminium conductors of rectangular section, covered with two or more layers of paper, primarily intended for transformer windings.

1.2 Sizes — The requirements of the standard are applicable to conductors having thicknesses from 0.80 up to and including 5.6 mm and widths from 2 up to and including 16 mm. A schedule of preferred sizes is given in IS : 6160 - 1971*.

*Specification for rectangular conductors for electrical machines.

†Rules for rounding off numerical values (revised).

IS : 6162 (Part II) - 1971

1.3 Grades of Covering — Two grades of covering are specified:

- a) *Double Paper Covered* — with a minimum total increase in dimensions of 0.25 mm due to covering; and
- b) *Multiple Paper Covered* — with more than two layers of paper.

Note — Edgewise bending paper-covered conductors conforming to this standard are not necessarily suitable for severe edgewise bending. Any special test requirements should be agreed between the manufacturer and the purchaser.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Wire — The insulated material as received.

2.2 Conductor — The bare metal after removal of the paper covering.

2.3 Increase in Dimensions Due to the Covering — The difference between the width or thickness over the paper covering and the corresponding dimension of the conductor.

2.4 Tolerance — The permissible divergence of an actual magnitude from that prescribed.

2.5 Butt Wound — Paper applied in tape form in such a manner that the edge of each turn butts against the edge of the preceding turn.

Note — In order to avoid a possible gap between the two successive turns of paper, an overlap of up to 1 mm is permissible.

2.6 Overlap Wound — Paper tape wound with each turn overlapping the preceding turn by not less than 25 percent of the paper width.

2.7 Groups of Papers — Three or four layers of paper applied in one operation.

3. GENERAL TEST CONDITIONS

3.1 Unless otherwise specified, all tests shall be carried out within a temperature range of 10 to 40°C, and at a relative humidity not greater than 85 percent. Before measurements are made, the specimens shall be preconditioned under these atmospheric conditions for a time sufficient to allow specimens to reach stability.

3.2 The wire to be tested shall be removed from the packaging in such a way that the wire will not be subjected to tension or unnecessary bends.

3.3 Before each test sufficient wire shall be discarded to ensure that any damaged wire is not included in the test specimens.

3.4 When no specific range of sizes is given for a test, the test is applicable to all sizes.

4. CONDUCTOR

4.1 The conductor shall fully conform to 3.2 of IS : 6160-1971*.

5. PAPER

5.1 Grade of Paper — The paper, before application, shall be free from metallic and other injurious inclusions, shall have no deleterious effects on insulating oil and shall be of such a quality that it will satisfy the requirements of 5.2 to 5.8.

5.2 Thickness — The thickness of the paper used shall be between the limits of 0.025 and 0.13 mm, both inclusive.

5.2.1 The measurement of thickness shall be done in accordance with 7 of IS : 1060 (Part I) - 1966†.

5.3 Tensile Strength — The tensile strength of the paper, when determined in accordance with 12.3 of IS : 1060 (Part I) - 1966† shall be not less than 55‡ MN/m² in the longitudinal direction and 20‡ MN/m² the transverse direction.

5.4 Ageing (Bursting Strength) Test — The bursting strength of the paper shall be determined as described in Appendix A, before and after the heat ageing treatment described in the same Appendix. The decrease in the bursting strength of the paper due to the heat treatment shall not exceed 20 percent.

5.5 pH Value of Water Extract — The pH value of water extract of the paper when determined by the method described in Appendix K of IS : 1576 - 1967§ shall be not less than 6.5 and not more than 8.0.

5.6 Conductivity of Water Extract — The conductivity of the water extract of the paper, when determined as described in Appendix C shall be not greater than 22 microsiemens per centimetre.

5.7 Oil Absorption — The height to which the oil shall rise in either the longitudinal or the transverse direction of paper, when it is tested as described in Appendix D shall be between the appropriate limits given in Table 1.

5.8 Ageing in Oil — The tensile strength of the paper when determined in accordance with 12.3 of IS : 1060 (Part I) - 1966† before and after

*Specification for rectangular conductors for electrical machines.

†Methods of sampling and test for paper and allied products: Part I (revised).

‡Mega newton.

§Specification for solid pressboard for electrical purposes.

IS : 6162 (Part II) - 1971

keeping the specimens in insulating oil, as described in 5.8.1 shall indicate the measure for ageing. The difference between the two values shall be not more than 25 percent of the first value.

TABLE 1 OIL ABSORPTION

(Clause 5.7)

NOMINAL THICKNESS OF PAPER	HEIGHT OF RISE OF OIL
mm	mm
(1)	(2)
0.13	45 to 75
0.10	40 „ 70
0.075	35 „ 65
0.065	30 „ 60
0.050	25 „ 55
0.038	20 „ 50
0.025	15 „ 45

5.8.1 From the test piece, twelve test strips 250×15 mm shall be taken in the longitudinal direction and twelve in the transverse direction. They shall be stored in insulating oil at 105°C for 7 days.

6. APPLICATION OF PAPER

6.1 General— To prevent the inclusion of aluminium dust or other extraneous matter under the paper covering the conductor shall be fully cleaned by felt pads or other suitable means immediately before entering the paper covering machine. Each layer of paper shall be continuous, firmly applied and substantially free from creases. No bonding or adhesive material shall be used except to anchor the ends of paper. Any such bonding or adhesive material shall have no deleterious effect on transformer oil, insulating paper or the electric strength of the covering. Where more than two layers of covering are used, the outermost layer shall be the thickest.

6.2 Width of Paper— Unless otherwise agreed between the manufacturer and the purchaser, the width of paper for different butt apping layers shall not exceed 1.5 times the sum of the width and thickness of the conductor with a maximum of 25 mm.

6.3 Arrangement of Layers— According to the number of layers used, the paper shall be applied as follows:

- a) **Two Layers**— When there are two layers, both of them shall be overlap wound in the opposite directions.

- b) *More than Two Layers* — All the layers shall be applied in the same direction; all except the outermost layer shall be butt wound, and the outermost layer shall be overlap wound. Within each group of papers the position of the butt joints of any layer relative to the layer below shall be progressively displaced by approximately 30 percent of the paper width.

NOTE — Layer arrangements differing from those specified in this clause may be adopted by agreement between the manufacturer and the purchaser provided that the insulated conductor meets all other requirements of this standard.

7. INCREASE IN CONDUCTOR DIMENSIONS DUE TO COVERING

7.1 Increase in Dimensions — The increase in dimensions due to the covering shall not exceed that specified nor shall it be less than that specified by more than the appropriate tolerance stated in Table 2.

TABLE 2 TOLERANCE ON COVERING

INCREASE DUE TO THE COVERING mm	TOLERANCE, PERCENT
(1)	(2)
0.25 to 0.5, inclusive	10
Over 0.5 up to and including 1.3	7.5
Over 1.3	5

7.2 Measuring Equipment — The measurement shall be made with an accuracy better than 0.002 mm. If a micrometer is used, it shall be ensured that the measuring force is in the range of 0.75 to 3.0 N. The spindle and the anvil of the micrometer shall have a diameter of 5 to 8 mm.

7.3 Measuring Method

7.3.1 Overall¹ Dimensions — Measurements shall be made of both dimensions of the covered conductor at three positions not less than 100 mm apart. The measurements shall be made on completely straight parts of the wire.

Where the dimensions of the covered conductor is greater than the diameter of the micrometer spindle, measurements shall be made both at the centre of the face of the wire and over the edges. If the values differ, the highest value only shall be noted.

The average of the three results for each dimensions shall be reported as the 'overall width' and 'overall thickness'.

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7.3.2 Conductor Dimensions — The covering shall be removed by any method which does not damage the conductor for the three positions used for measurements in 7.3.1 and the conductor dimensions measured at these positions.

The average of the results shall be reported as 'conductor width' and 'conductor thickness'.

7.3.3 Increase in Dimensions Due to Paper Covering — The difference between the overall width and the conductor width shall be reported as the 'increase in width'.

The difference between the overall thickness and conductor thickness shall be reported as 'increase in thickness'.

8. ELECTRIC STRENGTH (PROOF) TEST

8.1 If required by the purchaser, an electric strength test shall be carried out by the method described in Appendix E on three samples of the form shown in Fig. 2. All the three samples shall withstand the appropriate test voltage shown in Fig. 3, between adjacent conductors for 10 seconds without breakdown.

9. PACKING AND MARKING

9.1 The paper covered rectangular conductor shall be tightly and evenly wound on drums (see IS : 2069 - 1962*) in such a direction, that when unrolled the exposed edge of the overlap of the outer layer of paper is towards the drum.

9.1.1 The label which is to be securely attached to the drum shall have the following information:

- a) Manufacturer's name or trade-mark;
- b) Grade of covering;
- c) Conductor dimensions;
- d) Weight of wire; and
- e) Number of lengths, if there is more than one length of wire in one drum.

9.1.2 When more than one length is wound on the same drum the different lengths shall not be anchored with each other but strips of paper having colour distinctly different from that of the paper covered conductor shall be placed between the adjacent lengths to mark the start of the next length.

*Specification for drums for covered winding wires and strips for electrical purposes.

AMENDMENT NO. 1 AUGUST 1974
TO
IS : 6162 (Part II)-1971 SPECIFICATION FOR
PAPER COVERED ALUMINIUM
CONDUCTORS
PART II RECTANGULAR CONDUCTORS

Alterations

(Page 4, clause 3.1)

- a) *Line 2* — Substitute '15 to 35°C' for ' 10 to 40°C'.
- b) *Lines 2 and 3* — Substitute ' relative humidity range of 45 to 75 percent ' for ' relative humidity not greater than 85 percent'.

(ETDC 33)

AMENDMENT NO. 2 NOVEMBER 1975
TO
IS : 6162 (PART II)-1971 SPECIFICATION FOR
PAPER COVERED ALUMINIUM CONDUCTORS
PART II RECTANGULAR CONDUCTORS

Alterations

(Page 4, clause 2.3, line 2) — Delete the words ' width or '.

(Pages 7 and 8, clause 7.3) — Substitute the following for the existing clause:

"7.3 Measuring Method

7.3.1 Overall Dimensions — Measurements shall be made of the smaller dimension of the covered conductor at three positions not less than 100 mm apart. The measurements shall be made on completely straight parts of the wire. The measurement shall include at least one overlap.

Where the larger dimension of the covered conductor is greater than the diameter of the micrometer spindle, measurements shall be made at the centre of the wire.

The average of the three results shall be reported as the 'overall thickness'.

7.3.2 Conductor Dimensions — The covering shall be removed by any method which does not damage the conductor for the three positions used for measurements in 7.3.1 and the conductor dimension measured at these positions.

The average of the three results shall be reported as 'conductor thickness'.

7.3.3 Increase in Dimensions Due to Paper Covering — The difference between the overall thickness and the conductor thickness shall be reported as the 'increase in thickness'.

NOTE — The measurement across the larger dimension is under consideration."



AMENDMENT NO. 4 JANUARY 1984

TO

IS : 6162 (Part II) - 1971 SPECIFICATION FOR PAPER-COVERED ALUMINIUM CONDUCTORS

PART II RECTANGULAR CONDUCTORS

Addenda

(*Page 9, clause 9.1.3, Note*) — Add the following new clauses after 9.1.3 (*Note*):

‘ 10. SAMPLING

10.1 A recommendatory sampling plan and criteria for acceptance of lot are given in Appendix F.

10.2 Acceptance Tests — The following tests shall constitute acceptance tests:

- a) Conductor dimensions (*see 4*),
- b) Arrangement of paper layers (*see 6.3*),
- c) Increase in dimension (*see 7.1*), and
- d) Overall dimension (*see 7.3*).’

(*Page 17, Fig. 3*) — Add the following new Appendix after Fig. 3:

A P P E N D I X F

(*Clause 10.1*)

SAMPLING OF PAPER-COVERED ROUND ALUMINIUM CONDUCTORS

F-1. SCALE OF SAMPLING

F-1.1 Lot — In a consignment, all the drums of paper covered round aluminium conductors of the same grade and size manufactured from the same material in the same factory under similar conditions of production shall be grouped together to constitute a lot.

F-1.2 The number of drums to be selected from each lot shall depend upon the size of the lot and shall be in accordance with col 1 and 2 of Table 3.

TABLE 3 SAMPLE SIZE AND ACCEPTANCE NUMBER

(Clauses F-1.2 and F-2.1)

LOT SIZE	SAMPLE SIZE	ACCEPTANCE NUMBER
(1)	(2)	(3)
Up to 50	8	0
51 „ 100	13	0
101 „ 300	20	1
301 „ 500	32	2
501 and above	50	3

F-1.2.1 These drums shall be selected from the lot at random. In order to ensure the randomness of selection, procedure given in IS : 4905-1968* may be followed.

F-2. NUMBER OF TESTS AND CRITERIA FOR CONFORMITY

F-2.1 From each of the drums selected at random according to col 1 and 2 of Table 5, suitable lengths of test samples shall be taken after discarding approximately 1.5 metre of the wire. The number of tests to be carried out for each of the acceptance tests shall be in accordance with col 1 and 2 of Table 6. For this purpose suitable number of test samples shall be taken from each of the selected drums and subjected to the tests. A sample failing to satisfy any of the acceptance tests shall be considered as defective. The lot shall be considered as conforming to the requirements of acceptance tests if the number of defectives found in the sample is less than or equal to the corresponding acceptance number given in col 3 of Table 5, otherwise the lot shall be rejected.'

*Methods for random sampling.

AMENDMENT NO. 3 AUGUST 1978
TO
IS : 6162 (Part II)-1971 SPECIFICATION FOR
PAPER COVERED ALUMINIUM
CONDUCTORS

PART II RECTANGULAR CONDUCTORS

Addendum

(*Page 8, clause 8.1*) — Add the following new clauses after 8.1:

‘8.2 The test voltage may also be calculated by applying the formula as given below, since sometimes it is difficult to judge accurately the values from Fig. 3:

$$\log V_{10} = 1.544 + 0.8 \log t_{10}$$

where

V = proof voltage in kV, and

t = increase in dimension in mm due to covering.

NOTE — This formula is limited for the value of ‘ t ’ up to and including 5.080 mm.

8.2.1 In cases of disputes, the calculated value of proof voltage by the empirical formula shall prevail.’

9.1.3 The label may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

A P P E N D I X A

(Clause 5.4)

DETERMINATION OF AGEING BY BURSTING STRENGTH TEST

A-1. GENERAL

A-1.1 The bursting strength of the paper before and after the heat treatment is determined on samples cut from the same sheet.

A-1.2 Not fewer than 15 portions of paper, each of sufficient size to provide a pair of test specimens, are taken at random from the bulk. Each portion is halved so as to provide two sets of specimens, one of which is tested after conditioning only and the other after completion of heat-ageing treatment described in **A-2.1** and subsequent conditioning.

A-1.3 The specimens to be conditioned only are subjected to the treatment specified in Appendix B and the bursting strength is determined in the controlled atmosphere or as soon as possible after removal from it and in any case within 3 minutes of removal.

A-2. CONDITIONING

A-2.1 The specimens to be subjected to heat-ageing treatment are heated by suspending in a suitable oven, care being taken to prevent direct radiation from the heater falling on the specimens. The specimens are so suspended that there is at least a space of 25 mm between the sides, adjacent specimens and not less than 50 mm between them and the sides, top and bottom of the inner casing (or baffles). The specimens shall be heated at a temperature of $150 \pm 3^{\circ}\text{C}$ for 24 hours and then subjected to the controlled atmosphere described in Appendix B for 18 to 24 hours. The bursting strength is determined in the controlled atmosphere or as soon as possible after removal from it and in any case within 3 minutes of removal.

A-3. DETERMINATION OF BURSTING STRENGTH

A-3.1 Method — The method consists of measuring the pressure required to burst by a disk of paper which is gripped firmly round its periphery, and to one side of which pressure is applied at a uniform rate, using liquid as a medium, a flexible impervious membrane being interposed between paper and medium.

A-3.2 Apparatus — The method is based on the use of machines of the Mullen type, in which the specimen of paper is clamped firmly and evenly between two ring clamps so as to encircle a disk of 30.5 ± 0.01 mm diameter.

The flexible membrane (usually made of soft rubber) is sited immediately beneath the paper and is sufficiently thin and flexible not to affect materially the bursting pressure. The pressure gauge, calibrated to indicate kilograms and fractions of a kilogram per square centimetre of test piece, has an accuracy of ± 1 percent. The calibration range of the gauge is such that the test readings fall between 15 and 85 percent of the scale.

A-3.3 Testing of Specimens

A-3.3.1 The specimen is inserted between the clamps of the machine, which are then carefully tightened so as to grip the paper firmly, and the gauge pointer is adjusted to zero.

The pressure is applied smoothly by operation of the control mechanism at the rate specified for the machine.

When the specimen bursts, the pressure control handle is returned to its original position, the clamps are released and the indicated bursting pressure in kilogram per square centimetre is recorded.

A-3.3.2 Ten tests are made on each set of specimens, five with one side of the paper uppermost and five with the other side uppermost. If in any set of ten tests one result differs by more than 20 percent from the arithmetic mean of the ten, it is recorded but not used to calculate the bursting strength.

A-3.3.2.1 If more than one result so differs, four further specimens of that set are tested (two with one face uppermost and two with the other). The arithmetic mean of the ten results or, if one has been discarded, of the nine remaining results; or if fourteen specimens have been tested, of the twelve results showing least divergence from the mean, are deemed to be the bursting strength of that set of specimens.

Note — Slipping of test specimens in the clamps, because of insufficient or uneven pressure between them, can be recognized by the appearance of creases in the burst specimen. Any such test is disregarded.

A-3.4 Reporting of Results — The results are reported as follows:

- a) The bursting strength in kilogram per square centimetre before and after heat ageing treatment, and
- b) The results of any tests which because of excessive variation were not included in the final calculation of bursting strength.

APPENDIX B

(*Clauses A-1.3 and A-2.1*)

CONDITIONING OF PAPER SPECIMENS FOR TEST

B-1. CONDITIONING

B-1.1 Single sheets of paper shall be conditioned in a controlled atmosphere for 18 to 24 hours. The controlled atmosphere shall have a relative humidity of 65 ± 2 percent and a temperature of $27 \pm 2^\circ\text{C}$. Every specimen shall be tested in the controlled atmosphere or as soon as possible after removal from it and in any case within 3 minutes.

B-1.2 Where a test room having a controlled atmosphere is not available, a relative humidity of 65 ± 2 percent may be obtained conveniently in an enclosed chamber in which a saturated solution of a mixture of sodium chloride (NaCl) and sodium nitrate (NaNO_3) is exposed to the atmosphere in the chamber at the required temperature of $27 \pm 2^\circ\text{C}$. The saturated solution shall be prepared by boiling in water a mixture of one part by weight of sodium chloride, and two and a quarter parts by weight of sodium nitrate. The solution shall be then cooled and more of the solid mixture is added than can be taken into solution.

B-1.3 The saturated solution should be exposed so that the maximum surface is in contact with the air in the chamber, for example, by covering the floor of the chamber with a tray containing the saturated solution. There should be an excess of solid salt in the liquid to ensure that the solution remains saturated. It is important that the solid should remain covered by the solution and that the surface of the liquid should be free from any crust or film of grease, dirt, etc.

B-1.4 To ensure uniform conditions throughout the chamber, a fan should circulate air over the surface of the saturated solution and around the specimens. Care should be taken to allow free access of the conditioning atmosphere to all the specimens.

APPENDIX C

(Clause 5.6)

DETERMINATION OF CONDUCTIVITY OF WATER EXTRACT

C-1. APPARATUS

C-1.1 The apparatus for measurement of conductivity shall comprise of a suitable conductivity cell in conjunction with a bridge circuit supplied with current at a frequency of 500 to 3 000 Hz.

C-2. PREPARATION OF EXTRACT

C-2.1 The distilled water used throughout this test shall have a conductivity not greater than 2 microsiemens per centimetre. A blank test shall be carried out before each extraction and if the resultant conductivity exceeds 2 microsiemens per centimetre the test shall be repeated with the same extraction vessel. If the second result also exceeds 2 microsiemens per centimetre the vessel shall be discarded.

C-2.2 To prepare the extract, cut the paper into strips about 20×3 mm and put a weight of paper in the ratio of one gram of the strips to 100 ml of distilled water, into a 250-ml round-bottomed borosilicate glass (high grade resistance glass) or quartz flask fitted with a reflux condenser of either the same quality glass or quartz. The apparatus shall have interchangeable conical ground glass joints. Boil the water gently for 10 minutes, care being taken not to char the paper.

C-3. METHOD OF MEASUREMENT

C-3.1 Determine the cell constant K , if not known, by means of a solution of known conductivity, prepared by dissolving 0.074 g of dry potassium chloride in distilled water and diluting the solution to 1 000 ml at a temperature of $27 \pm 1^\circ\text{C}$. Thoroughly rinse out the cell with the solution and fill. The temperature shall be adjusted to $27 \pm 1^\circ\text{C}$ and maintained at that value for 15 minutes before as well as during the measurement of resistance.

C-3.2 Carry out the test of water extract as described above, as soon as practicable after the preparation of the extract.

C-4. CALCULATION

C-4.1 The cell constant $K = R \times (147.4 + C)$

$$\begin{array}{l} \text{Conductivity of water extract in} \\ \text{microsiemens per centimetre} = \frac{K}{R_1} - C_1 \end{array}$$

where

R = measured resistance of potassium chloride solution in megohms,

C = conductivity of distilled water in microsiemens per centimetre,

R_1 = measured resistance of the water extract in megohms, and

C_1 = conductivity of the blank in microsiemens per centimetre.

NOTE — For most purposes, where it is not convenient to test the water extract at $27 \pm 1^\circ\text{C}$, it is sufficiently accurate to apply the following correction:

$$\text{Conductivity at } 27^\circ\text{C} = \frac{X}{1 \pm 0.02 t}$$

where X is the conductivity obtained when measurement is made at $t^\circ\text{C}$ above or below 27°C ; $0.02 t$ being added when measurement is made above 27°C and subtracted when made below 27°C .

APPENDIX D

(Clause 5.7)

DETERMINATION OF OIL ABSORPTION

D-1. GENERAL

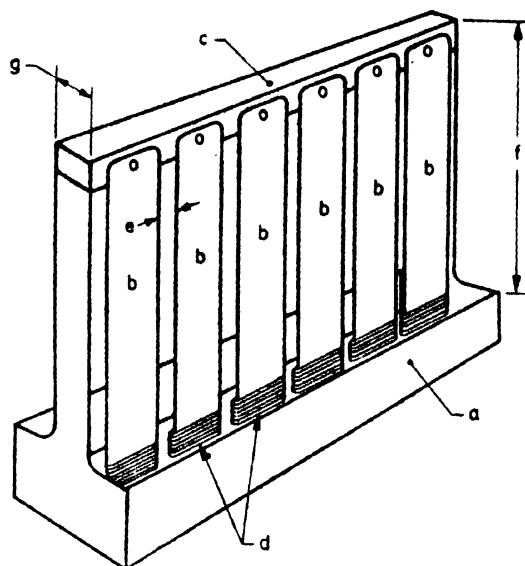
D-1.1 The absorption of oil by the paper is determined in the machine (longitudinal) direction, and in the cross (transverse) direction.

D-2. PREPARATION OF SAMPLES

D-2.1 The oil absorption test is carried out on six strips of paper 200 mm long and 50 mm wide of which three strips are cut in the machine direction and three in the cross direction of the paper. The strips are cut in pairs, one pair from each edge and one pair from the centre of the roll or sheet. A line is marked across each specimen exactly 12.5 mm from the lower end.

D-3. METHODS OF TEST

D-3.1 All the specimens are pinned vertically to the suspension bar, which is fixed above a suitable tank as shown in Fig. 1, so that the top end of each specimen is level with the top of the bar. Small lead clips are attached to the lower ends of the specimens to serve as weights.



a	400 × 75 × 45
b	200 × 50
c	400 × 20 × 20
d	50 × 6.5 × 1.5
e	13 Min, spacing
f	180
g	20

All dimensions in millimetres.

FIG. 1 APPARATUS FOR OIL ABSORPTION TEST

D-3.2 The apparatus with the specimens attached is placed in an oven with a quantity of insulating oil complying with IS: 335-1963* in a separate vessel. The temperature of the oven is between 95°C and 100°C. The apparatus and oil are allowed to remain in the oven for not less than one hour and sufficient oil is then transferred carefully to the tank by means of a funnel so that the surface of the oil is coincident with the lines marked on the specimens. The apparatus is maintained at a temperature between 95°C and 100°C for 2 hours. The height to which the oil rises in each specimen after 2 hours is noted.

*Specification for insulating oil for transformers and switchgear (*revised*).

APPENDIX E

(Clause 8.1)

METHOD OF APPLICATION OF THE ELECTRIC STRENGTH (PROOF) TEST

E-1. PREPARATION OF SPECIMENS

E-1.1 Test specimens shall be prepared as shown in Fig. 2.

E-2. CONDITIONING

E-2.1 The prepared specimen is dried at 95 to 105°C in a vacuum of not less than 710 mm of mercury for not less than 24 hours. It is then immersed in insulating oil complying with IS : 335 - 1963* at a temperature of 90 to 95°C for not less than 24 hours, without breaking the vacuum. If the testing of the specimen does not follow immediately after conditioning, the specimen is left immersed in the oil which may be allowed to cool to room temperature.

E-3. METHOD OF TEST

E-3.1 At the end of the immersion period and without removal from the oil, the test specimen shall be subjected to the specified test voltage between adjacent conductors. The oil is maintained at a temperature between 85°C and 95°C during the test and for at least half an hour beforehand.

E-3.2 The test voltage shall be alternating and of a frequency of approximately 50 Hz. The test voltage shall be of approximately sine-wave form and the ratio of the peak value to the rms value shall be within the limits $\sqrt{2} \pm 5$ percent (1.34 to 1.48).

E-3.3 The test voltage shall be expressed as peak value divided by $\sqrt{2}$, and shall be determined by means of a peak voltmeter suitably connected across the output winding of the transformer or by means of rms voltmeter connected across the input or output winding and calibrated against a sphere gap connected to output terminals of the transformer.

E-3.4 The voltage shall be raised at such a rate that the full test voltage is reached in not more than five seconds for test voltages up to 20 kV and for voltage above 20 kV the voltage shall be raised at the rate specified below until the appropriate voltage shown by the curve in Fig. 3 is reached. The voltage shall be maintained for ten seconds and no breakdown shall occur.

*Specification for insulating oil for transformers and switchgear (revised).

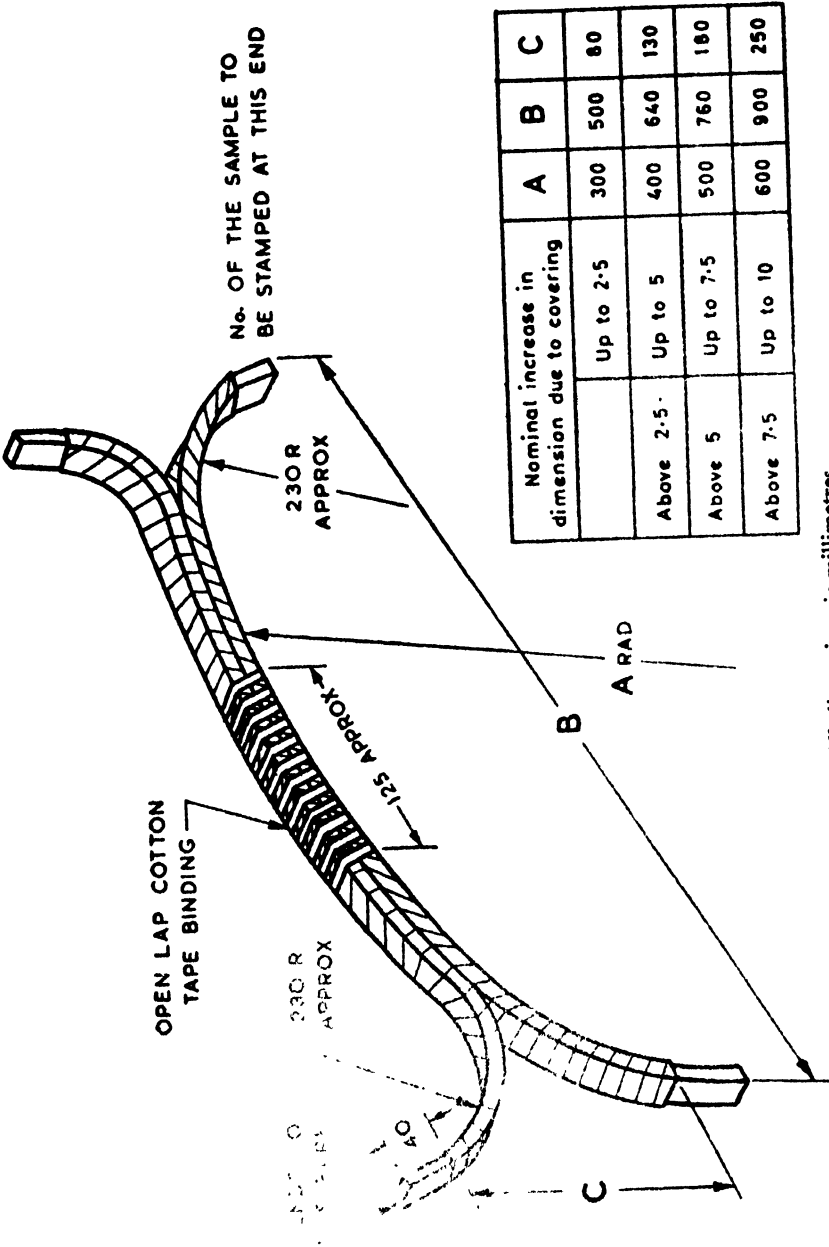
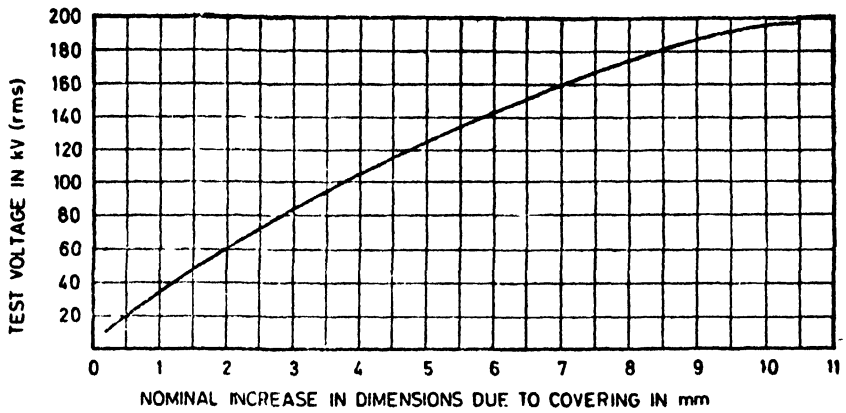


FIG. 2 FORM OF SAMPLE FOR ELECTRIC STRENGTH TEST FOR PAPER-COVERED RECTANGULAR CONDUCTORS



Proof Test Voltage

kV

Up to 30

30 „ 60

60 „ 100

Above 100

Rate of Increase

kV/s

1 to 2

2 „ 4

4 „ 6

6 „ 8

FIG. 3 TEST VOLTAGES FOR ELECTRIC STRENGTH (PROOF) TEST



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